ECOSYSTEM STATUS INDICATORS
Benthic Communities and Non-target Fish Species
Gulf of Alaska Small Mesh Trawl Survey Trends
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Small mesh shrimp trawl surveys have been conducted with standard methods in the Gulf of Alaska by the Alaska Department of Fish and Game and National Marine Fisheries Service since 1972 (n = 8,083 hauls). This data set has been particularly valuable in documenting the ecological reorganization that occurred following the 1976-1977 shift from a cold state of the Pacific Decadal Oscillation to a warm state (Piatt & Anderson 1996; Anderson & Piatt 1999). During 2004, sampling occurred in Marmot and Chiniak Bays, Shelikof Strait, and along the Alaska Peninsula coast between Wide and Pavlof Bays (n = 114 hauls). Several authors have suggested that another climate regime shift may have occurred in 1998-99 (Bond et al. 2003; Peterson and Schwing 2003), and increases in CPUE of Pandalid shrimp and eulachon *Thaleichthys pacificus* in small mesh trawls following 1998 have suggested the possibility of incipient climate-mediated community reorganization in the Gulf (Anderson 2004). The goal of this contribution is to assess the evidence for current ecological reorganization in small mesh survey data.

Community trends
Analysis of the data set is complicated by seasonal variability (i.e., sampling in different months during different years) and spatial variability (sampling of different bays in different years). In order to control these effects, analysis of variability in catch composition was limited to hauls set from July to October in the seven best-sampled bays on Kodiak Island and the Alaska Peninsula (Marmot, Kiliuda, Two-Headed Gully, Alitak, Chignik/Castle, Kuiukta and Pavlof; n = 1,744 hauls). Only one bay (Pavlof) was sampled each year, and the others were sampled between 14 and 18 of the 33 years. Nonmetric multidimensional scaling (NMDS) was used to summarize variability in the 30 most common taxa, which made up 98.8% of the total catch. NMDS summarizes variability in community composition in a restricted number of variables. This method is conceptually similar to principal components analysis, but is more robust to the presence of large numbers of zero catches that characterize trawl survey data (see Mueter and Norcross 1999, 2000 for detailed methods). The first three NMDS axes explained 34%, 24% and 20% of variability in catch composition, respectively. Only the first axis showed coherent temporal variability, while axis 2 primarily varied among bays and axis 3 primarily varied with depth. Axis 1 positively weighted taxa that increased after the 76-77 regime shift (jellyfish [Scyphozoa], arrowtooth flounder *Atheresthes stomias*, walleye pollock *Theragra chalcogramma*, flathead sole *Hippoglossoides elassodon*) and negatively weighted taxa that declined following the regime shift (Pandalid shrimp, capelin, Pacific sandfish *Trichodon trichodon*, red king crab *Paralithodes camtschaticus*, sculpins [Cottidae, Psychrolutidae, Hemitripteridae]; Figure 75). Similar results were obtained in a previous analysis of small mesh data from Kodiak Island bays (Mueter and Norcross 2000).
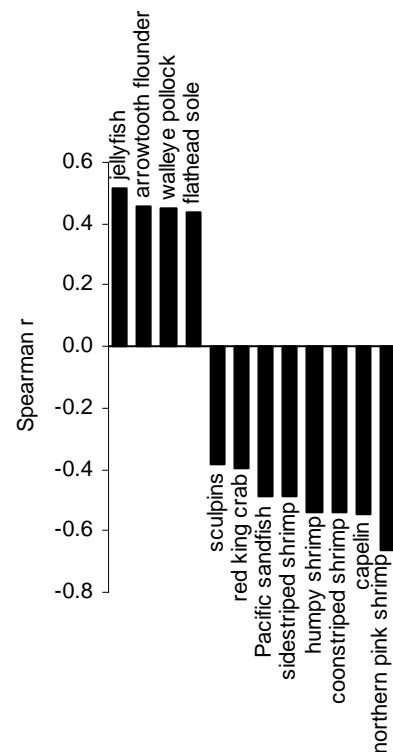

Figure 75. Associations between individual taxa and NMDS axis 1 in Gulf of Alaska small mesh trawls. Taxa with |r| > 0.35 are shown. Taxa with positive correlations increase in CPUE when axis 1 increases, taxa with negative correlations decrease when axis 1 increases.

In order to overcome the bias due to different bays being sampled in different years, bay-year values for axis 1 were estimated as the mean axis 1 score from every haul in a bay during a given year. Separate autoregressive error models (which account for the autocorrelation among errors that is present in time series data) were run for each bay time series. Predicted axis 1 values from the autoregressive models were used to estimate missing bay-year values, resulting in seven complete time series. Pavlof Bay was the only bay sampled in 1972, with two other time series (Chignik-Castle and Kuiukta) beginning in 1973 and the remainder beginning in 1976. Two averaged time series were therefore constructed, one beginning in 1973 (mean axis 1 scores from Pavlof, Chignik-Castle and Kuiukta), and another beginning in 1976 (mean axis 1 scores from all seven bays). An index of local climate was also calculated as the first principal component of five measures of local climate: winter and summer sea level pressure averaged over seven 1° x 1° blocks centered on the seven sampled bays (Pacific Fisheries Environmental Laboratory 2005), winter and summer sea surface temperature in a 5° x 5° block centered on Kodiak Island (Climatic Research Unit 2005), and summer GAK1 250 m temperature (Institute of Marine Science 2005).
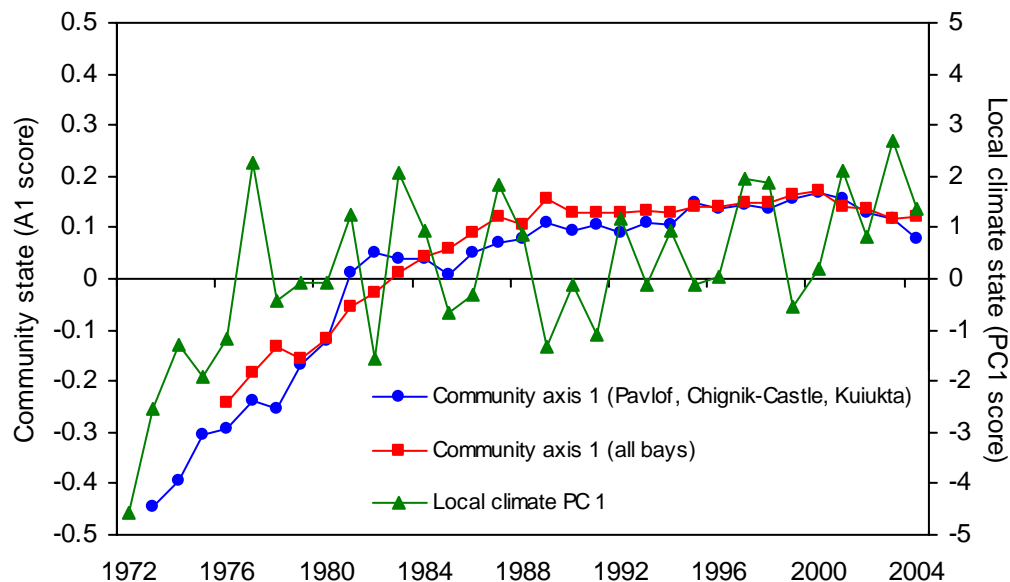

Figure 76. Trends in Gulf of Alaska community composition (NMDS axis 1 of small mesh trawl catches) and local climate (first principal component of summer and winter sea level pressure, summer and winter surface temperature and summer GAK1 250 m temperature). Trawl data are from seven bays on Kodiak Island and Alaska Peninsula during July-October, and have been corrected for effect of sampling different bays in different years. Two time series are presented, one for three bays that have been sampled since 1973, and another for all bays, beginning in 1976, the first year that all bays in the time series were sampled. See Figure 75 for interpretation of axis 1 scores.

All three time series showed a logarithmic increase with year (axis 1 for Pavlof, Chignik-Castle and Kuiukta, $r^2 = 0.92$; axis 1 for all bays, $r^2 = 0.88$; local climate PC1, $r^2 = 0.45$). This logarithmic pattern is consistent with a sudden climate shift in 76-77, a resulting sudden community transition following the 76-77 regime shift, and the completion of the transition to the current ecological state in the early 1980s (Figure 76). Axis 1 was positively correlated with local climate PC1 for the longer Pavlof/Chignik-Castle/Kuiukta time series ($r = 0.48$), but not for the shorter time series for all bays ($r = 0.16$, Figure 76). Although axis 1 scores have declined since 1999-2000, these scores have remained within the range

established after the early 1980s, and there is no evidence at this time of the kind of rapid community reorganization that followed the 1976-77 shift.

Trends in selected taxa

Although community-wide analysis shows no evidence of a current reorganization, changes in the three-year running mean CPUE of several taxa have been noted since 1998 (Anderson 2004). Calculation of running mean CPUE does not take into account seasonal and spatial differences in sampling among years, and this is an important caveat. Pavlof Bay has been sampled every year since 1972, while bays to the east of Pavlof on the Alaska Peninsula and Kodiak Island were sampled during triennial surveys in 1989, 1992, 1995 and 1998, and annually or biennially during 2001-2004. The increase in effort since 2001 has the effect of decreasing the contribution of Pavlof Bay to running mean CPUE estimates beginning in 2000 (the first year that includes 2001 data). Pavlof Bay shows consistent differences in CPUE from other sampled bays for a wide range of taxa, so annual differences in sampling distribution confound apparent temporal trends in running mean CPUE data.

In spite of these limitations in the data, increases in CPUE of some taxa (especially eulachon and spiny dogfish *Squalas acanthias*) are dramatic enough that they likely reflect significant changes in population size or distribution independent of changes in sampling distribution. CPUE data from selected taxa are presented here to provide insight into recent trends. Detailed 2004 catch data (excluding Pavlof Bay) are available elsewhere (Jackson 2005).

Pandalid shrimp CPUE in 2004 was generally similar to CPUE in recent years (northern pink shrimp *Pandalus borealis*, 22.0 ± 4.5 [SE] kg/km; humpy shrimp *P. goniurus*, 1.5 ± 0.7 kg/km; coonstriped shrimp *P. hypsinotus*, 0.02 ± 0.01 kg/km; sidestriped shrimp *Pandalopsis dispar* 1.4 ± 0.3 kg/km). The recent trend of dramatically higher eulachon catches continued, with 2004 CPUE of 11.6 ± 2.1 kg/km, the highest value ever observed in the time series. Capelin catches continued to be very low (0.02 ± 0.01 kg/km), following the trend since the 1980s of very low catches of this previously common species. Catches of Pacific sandfish continued at relatively high levels (2.1 ± 1.0 kg/km), similar to catches in the late 1970s and early 1980s, while longsnout pricklebacks *Lumpenella longirostris* continued to be caught at low levels (0.4 ± 0.2 kg/km) characteristic of their population levels since the 1970s. Recent trends of declining Gadid catches reversed in 2004. CPUE of both walleye pollock (192.7 ± 47.6 kg/km) and Pacific cod *Gadus macrocephalus* (22.7 ± 9.1 kg/km) were more than double values for 2001-2003. CPUE of two important flatfish species, arrowtooth flounder (35.8 ± 6.3 kg/km) and flathead sole (50.5 ± 8.6 kg/km), were similar to values for recent years, suggesting that populations of these species remain at high post-regime shift levels. Jellyfish CPUE (4.1 ± 0.8 kg/km) was one third of 2002-03 values, and an order of magnitude below 2001 CPUE. Finally, spiny dogfish CPUE (2.3 ± 0.4 kg/km) continued at unprecedented high levels that began in 1998.